Potenciálisan veszélyes (PHO) földközeli objektumok (NEO) becsapódási valószínűsége a Torino-skála alapján

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WJLF Környezetbiztonsági Tanszék (tanszéki munkatárs)

Wesley tudományos körkép 2024
WJLF, online, 2024.11.24.

A kozmikus becsapódási veszély

- A Shoemaker-Levy 9 üstökös darabjainak becsapódása a Jupiterbe 1994-ben (2009)

Forrás: https://youtu.be/yyMXE1qyATE?si=IpeyvOcYxvwWaf5n

Mindennapi kozmikus közelség

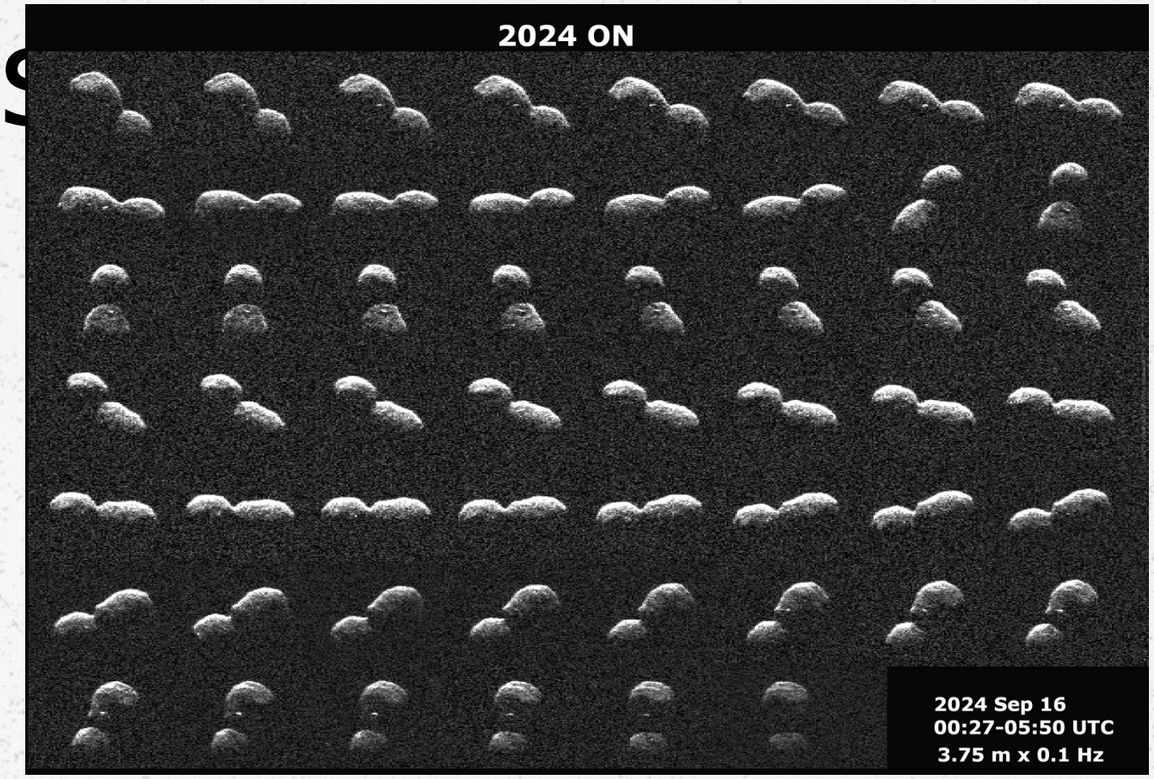
- @elsadoudiallo3930 (2024): An impressive blue "bolide" seen in the skies of Portugal and Spain

- A C/2023 A3 (Tsuchinshan–ATLAS) üstökös hazánk felett (2024)

Forrás: https://youtube.com/shorts/YMTFtg1crp0?si=d0Wlk6O5Q1GxIlOO

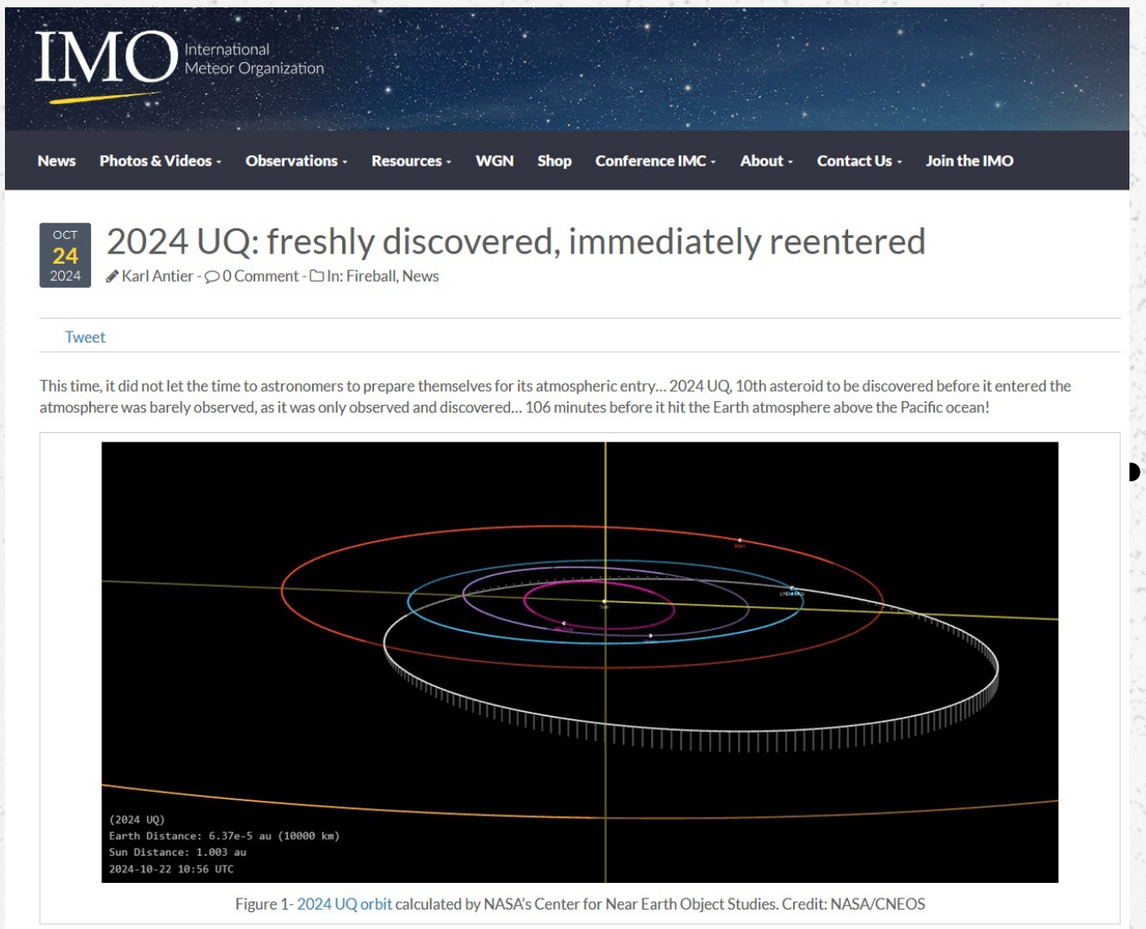
Forrás: Rezsabek N. felvétele

Mindennapi kozmikus veszélyeztetettség



- A Földet a Hold távolságának alig 2,6x-ára megközelítő 2024 ON kisbolygó

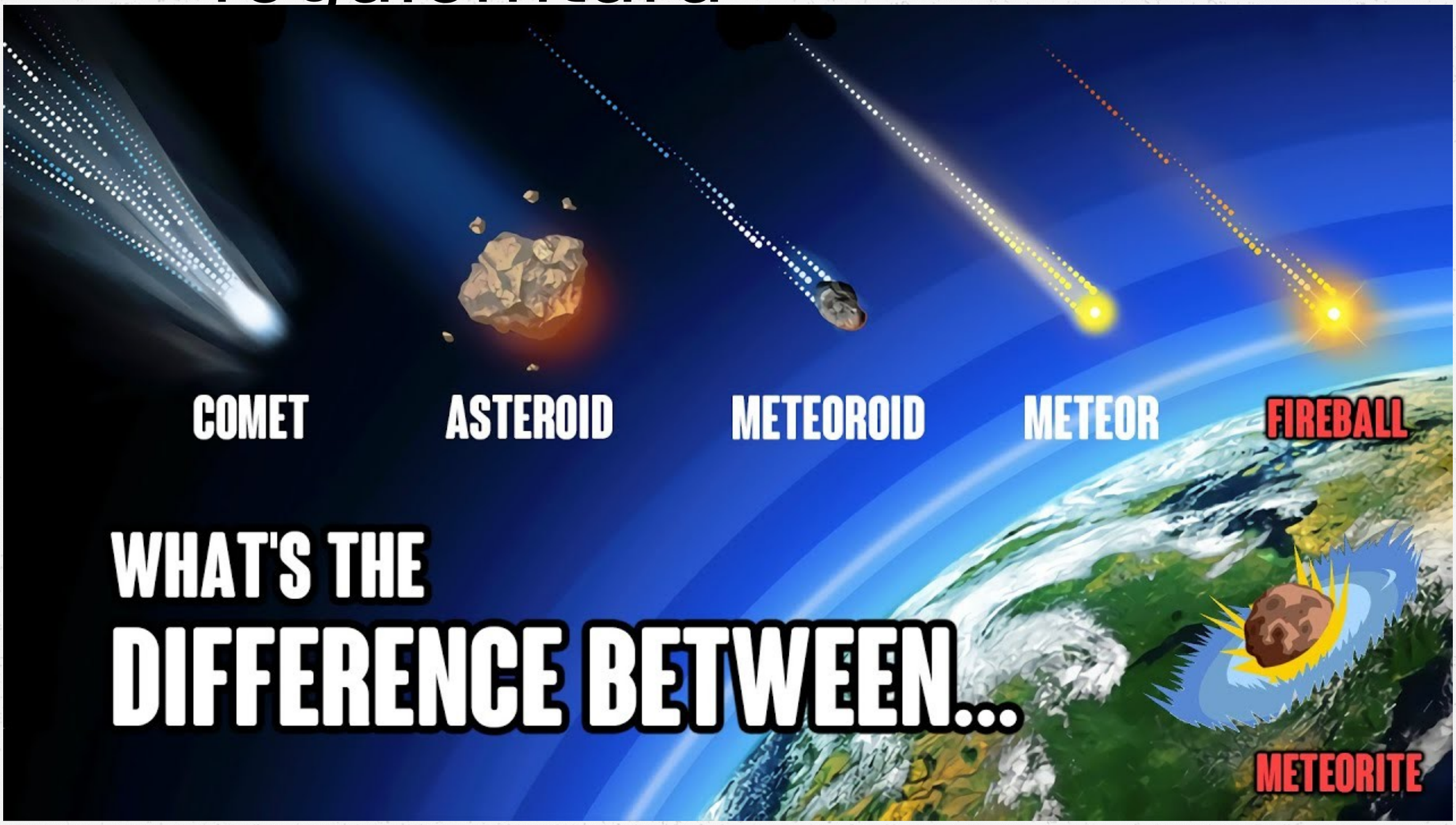
Forrás: https://www.jpl.nasa.gov/images/pia26451-nasas-planetary-radar-spies-another-peanut-shaped-



- A 2024 UQ kisbolygó Csendes-óceán feletti légkörbe lépésének előrejelzése (2024)

Forrás: https://www.imo.net/2024-uq-freshly-discovered-immediatly-reentered/

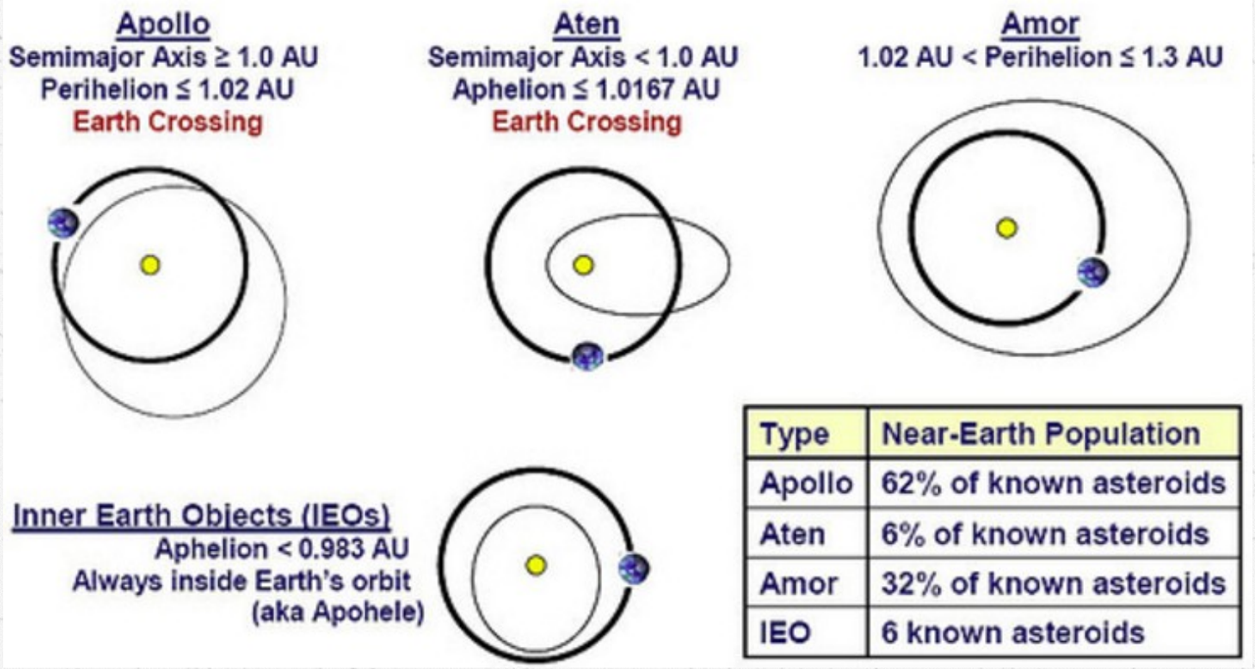
A kozmikus becsapódás fogalomtára



Forrás: https://youtu.be/i_8qeGDBJ5U?si=6sUq16_ksCUdPQ

A NEO-k kategorizálása

Group	Description	Definition
NECs	**N**ear-**E**arth **C**omets	*q*<1.3 AU, *P*<200 years
NEAs	**N**ear-**E**arth **A**steroids	*q*<1.3 AU
Atiras	NEAs whose orbits are contained entirely with the orbit of the Earth (named after asteroid 163693 Atira).	*a*<1.0 AU, *Q*<0.983 AU
Atens	Earth-crossing NEAs with semi-major axes smaller than Earth's (named after asteroid 2062 Aten).	*a*<1.0 AU, *Q*>0.983 AU
Apollos	Earth-crossing NEAs with semi-major axes larger than Earth's (named after asteroid 1862 Apollo).	*a*>1.0 AU, *q*<1.017 AU
Amors	Earth-approaching NEAs with orbits exterior to Earth's but interior to Mars' (named after asteroid 1221 Amor).	*a*>1.0 AU, 1.017<*q*<1.3 AU
PHAs	**P**otentially **H**azardous **A**steriods: NEAs whose Minimum Orbit Intersection Distance (MOID) with the Earth is 0.05 AU or less and whose absolute magnitude (H) is 22.0 or brighter.	*MOID*<=0.05 AU, *H*<=22.0



Type	Near-Earth Population
Apollo	62% of known asteroids
Aten	6% of known asteroids
Amor	32% of known asteroids
IEO	6 known asteroids

- A NEO-k és NEA-k típusai, a NEA-k pályái, valamint a PHA kategória (2016)

Forrás: https://astronomy.stackexchange.com/questions/18117/what-actually-defines-an-aten-class-near-earth-asteroi

Meteorithullások / hammer

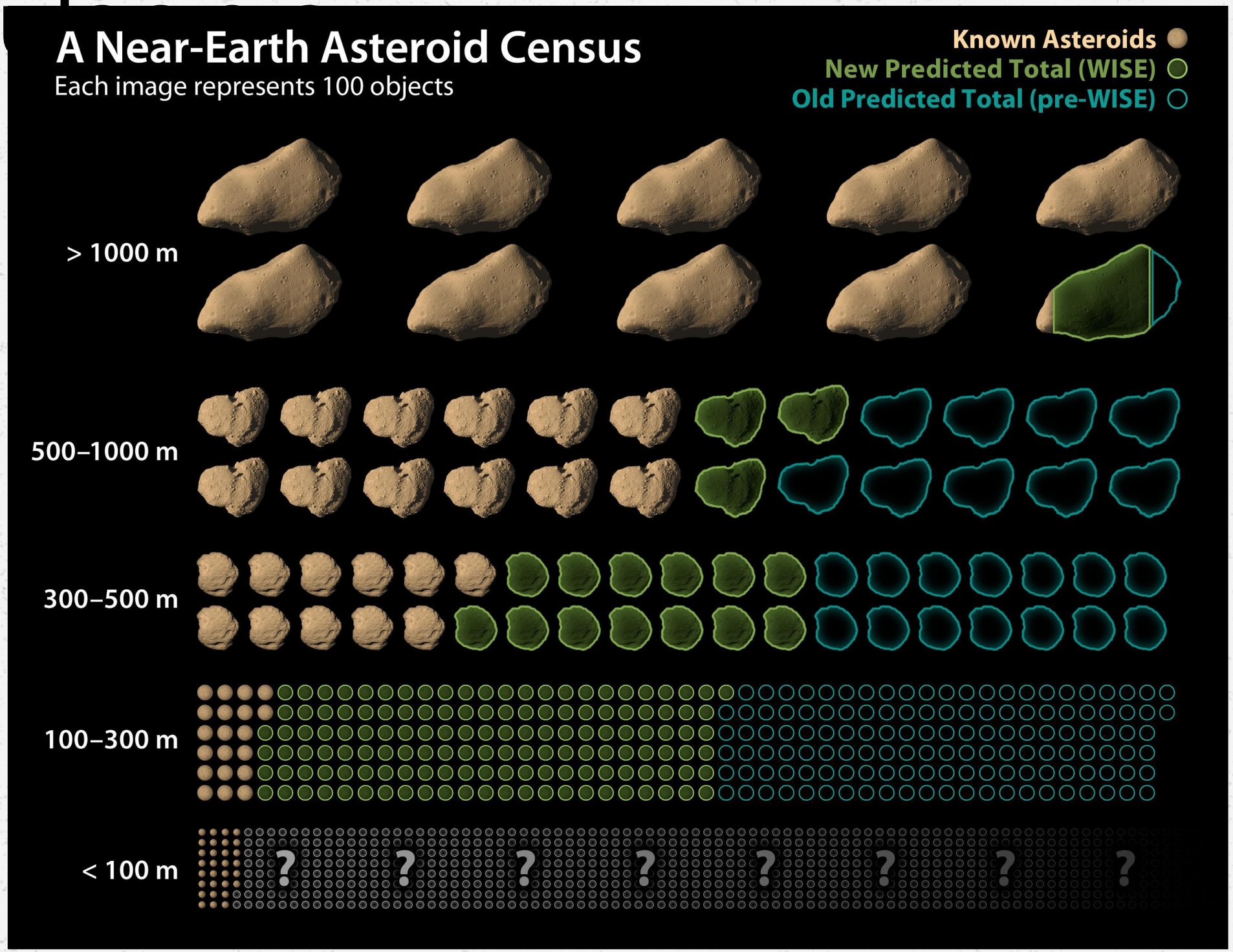
- Az utolsó magyarországi meteorithullás II. világháború alatti, 1944-es Mike Somogy vármegyében (2024)

- Nincs hiteles információ meteorithullás következtében elhunytakról; sérüléseket, infrastrukturális és anyagi károkat (2017) viszont több esetben is okozott

Forrás: Rezsabek N. felvétele

Forrás: https://meteoritecar.com/

A NEA-k populációja



- A katalogizált NEA-k az egyes mérettartományokban a NEOWISE program becslése alapján (2011)

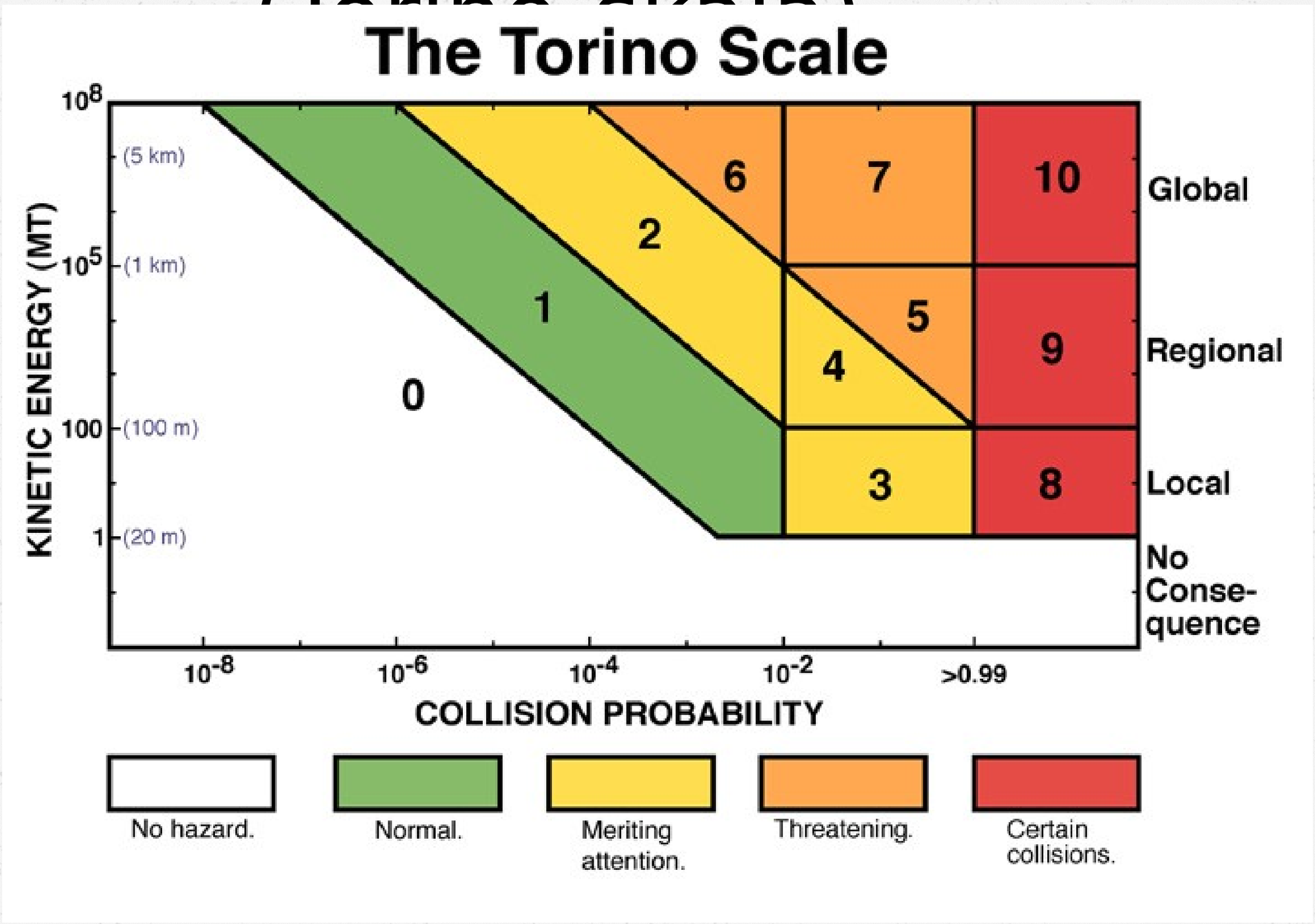
Forrás: https://www.planetary.org/space-images/wise-near-earth-asteroid

A NEO-k jelentette veszély számszerűsítése

- Tudományos probléma
  - A földközeli objektumok (NEO-k) által jelentett veszély számszerűsítése
- Tudományos eredmény
  - A **Torino-** (TS) és a Palermo**-skála** (PS) felállítása
  - A **NASA JPL CNEOS Sentry** és az ESA NEOCC monitoring rendszerében mutatószámként történő alkalmazása a potenciálisan veszélyes objektumok (PHO-k) esetében

Forrás: https://www.planetary.org/space-images/wise-near-earth-asteroid

A becsapódások valószínűsége, hatása, veszélye (Torino skála)



Forrás: https://web.archive.org/web/20070224184209/http://impact.arc.nasa.gov/images/torino_plot_big.jp

A becsapódások veszélye (Torino skála)

No Hazard (White Zone)	**0**	The likelihood of a collision is zero, or is so low as to be effectively zero. Also applies to small objects such as meteors and bodies that burn up in the atmosphere as well as infrequent meteorite falls that rarely cause damage.
Normal (Green Zone)	**1**	A routine discovery in which a pass near the Earth is predicted that poses no unusual level of danger. Current calculations show the chance of collision is extremely unlikely with no cause for public attention or public concern. New telescopic observations very likely will lead to re-assignment to Level 0.
Meriting Attention by Astronomers (Yellow Zone)	**2**	A discovery, which may become routine with expanded searches, of an object making a somewhat close but not highly unusual pass near the Earth. While meriting attention by astronomers, there is no cause for public attention or public concern as an actual collision is very unlikely. New telescopic observations very likely will lead to re-assignment to Level 0.
	3	A close encounter, meriting attention by astronomers. Current calculations give a 1% or greater chance of collision capable of localized destruction. Most likely, new telescopic observations will lead to re-assignment to Level 0. Attention by public and by public officials is merited if the encounter is less than a decade away.
	4	A close encounter, meriting attention by astronomers. Current calculations give a 1% or greater chance of collision capable of regional devastation. Most likely, new telescopic observations will lead to re-assignment to Level 0. Attention by public and by public officials is merited if the encounter is less than a decade away.
Threatening (Orange Zone)	**5**	A close encounter posing a serious, but still uncertain threat of regional devastation. Critical attention by astronomers is needed to determine conclusively whether or not a collision will occur. If the encounter is less than a decade away, governmental contingency planning may be warranted.
	6	A close encounter by a large object posing a serious but still uncertain threat of a global catastrophe. Critical attention by astronomers is needed to determine conclusively whether or not a collision will occur. If the encounter is less than three decades away, governmental contingency planning may be warranted.
	7	A very close encounter by a large object, which if occurring this century, poses an unprecedented but still uncertain threat of a global catastrophe. For such a threat in this century, international contingency planning is warranted, especially to determine urgently and conclusively whether or not a collision will occur.
Certain Collisions (Red Zone)	**8**	A collision is certain, capable of causing localized destruction for an impact over land or possibly a tsunami if close offshore. Such events occur on average between once per 50 years and once per several 1000 years.
	9	A collision is certain, capable of causing unprecedented regional devastation for a land impact or the threat of a major tsunami for an ocean impact. Such events occur on average between once per 10,000 years and once per 100,000 years.
	10	A collision is certain, capable of causing global climatic catastrophe that may threaten the future of civilization as we know it, whether impacting land or ocean. Such events occur on average once per 100,000 years, or less often.

Forrás: https://asteroidday.org/resources/event-resources/learn-how-do-we-categorize-potential-asteroid-or-comet-impact-event

A Földre potenciálisan veszélyes kisbolygók (PHA)

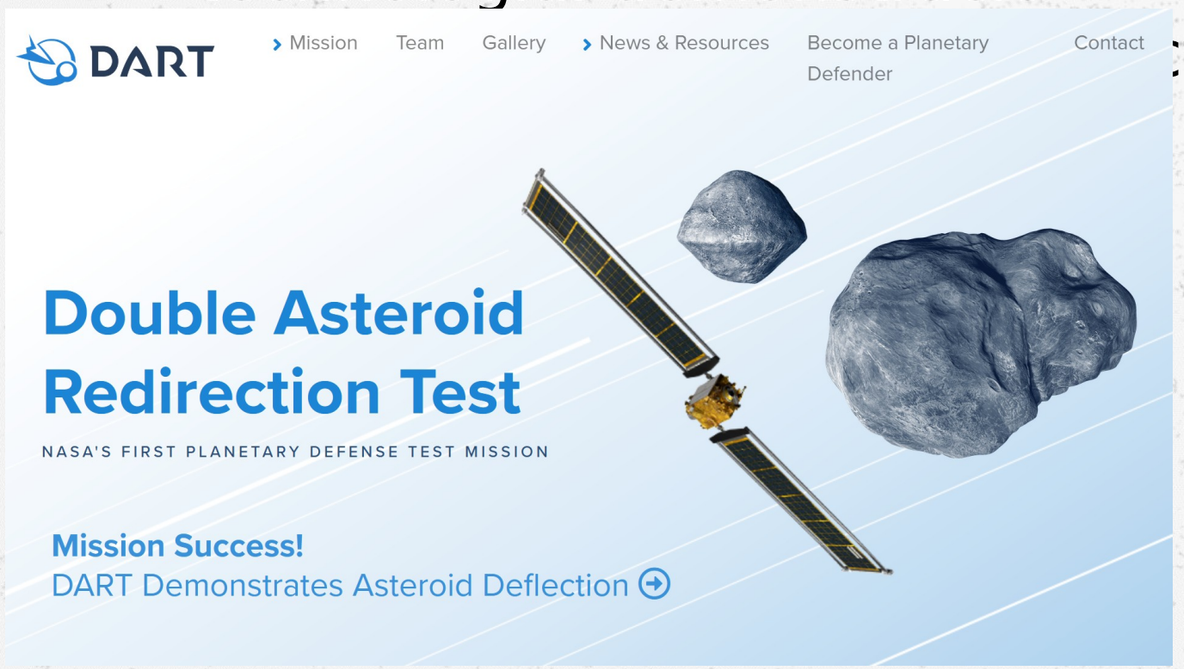
Object Designation	Year Range	Vinfinity (km/s)	H (mag)	Estimated Diameter (km)	Torino Scale (max.)
(2022 YO1)	2024-2044	14,42	30	0,003	0
(2013 TP4)	2026-2026	25,30	27,5	0,011	0
(2008 JL3)	2027-2122	8,42	25,3	0,029	0
(2024 TK5)	2028-2028	8,93	27,7	0,01	0
(2007 KE4)	2029-2096	10,06	25,2	0,031	0
(2005 QK76)	2030-2059	19,67	25,2	0,031	0
(2016 WN55)	2030-2114	NaN	26,4	0,017	0
(2021 GX9)	2032-2052	16,79	25,3	0,029	0
(2023 VD3)	2034-2042	17,78	27	0,013	0
(2007 DX40)	2035-2122	15,52	24,6	0,04	0
(2022 PX1)	2040-2040	35,11	22,3	0,12	0
(2008 UB7)	2044-2101	18,53	23,8	0,058	0
(2020 VV)	2044-2122	2,58	27,3	0,012	0
(2012 QD8)	2047-2120	20,76	23,1	0,081	0
(2019 VB37)	2049-2067	14,55	24,5	0,043	0
(2012 HG2)	2052-2122	3,32	27	0,014	0
(2008 EX5)	2056-2093	9,92	23,8	0,059	0
(2023 DO)	2057-2092	6,97	25,6	0,026	0
(2013 VW13)	2063-2095	16,35	26,2	0,019	0
(2000 SB45)	2067-2118	7,53	24,3	0,046	0
(2000 SG344)	2069-2122	1,36	24,8	0,037	0
(2024 BY15)	2071-2124	NaN	26,7	0,015	0
(2020 VW)	2074-2079	9,69	28,3	0,007	0
(2024 JW16)	2082-2121	23,93	21	0,22	0
(2017 WT28)	2083-2121	4,47	28,1	0,008	0
(2010 RF12)	2095-2122	5,10	28,4	0,007	0
(2024 QL1)	2104-2124	4,23	27,5	0,011	0
(2015 JJ)	2111-2111	10,70	22,1	0,13	0
(2016 YM4)	2121-2121	18,98	22,4	0,11	0
(2020 UL3)	2122-2123	10,19	23,2	0,076	0

- Az elkövetkező 100 év lehetséges becsapódási eseményei és azok Torino-skála szerinti veszélye a NASA JPL CNEOS Sentry monitoring rendszer adatai alapján (2024)

Forrás: https://cneos.jpl.nasa.gov/sentry

…és ha mégis?

- Hazai kitekintés / a kutatás jövőbeni irányai
  - Hazai NEA / Pre-Impact Detections kisbolygófelfedezések - HUN-REN CSFK KTM CSI
  - Hazai meteorkamera-hálózat - MMT
  - **Extraterresztrikus objektumok becsapódása és következményeinek kezelése a kritikus infrastruktúrák vonatkozásában - NKE HHK KMDI (Rezsabek N.)**
- Nemzetközi kitekintés / a kutatás jövőbeni irányai
  - Didymos-Dimorphos kisbolygó-hold - tudományos kísérlet / technológiai demonstráció



Forrás: https://dart.jhuapl.edu/

Forrás: https://www.esa.int/Space_Safety/Hera

Kapcsolódó szakirodalom

Antier, K. (2024): 2024 UQ: freshly discovered, immediately reentered. *IMO International Meteor Organization*, https://www.imo.net/2024-uq-freshly-discovered-immediatly-reentered/ [Hozzáférés: 2024.11.21.]

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Binzel, R.P. (2000): The Torino Impact Hazard Scale. *Planetary and Space Science* 48, 4, 297-303, https://doi.org/10.1016/S0032-0633(00)00006-4

ESA NEOCC Near-Earth Object Coordination Centre (2024): *Risk List* https://neo.ssa.esa.int/risk-list [Hozzáférés: 2024.10.21.]

Kereszturi Á. (1994): Egy üstökös pusztulása (In memoriam P/Shoemaker-Levy 9). In: Holl A. et al. (szerk.) *Meteor csillagászati évkönyv 1995.* Magyar Csillagászati Egyesület, Budapest, 143-153.

NASA JPL CNEOS Center for Near Earth Object Studies (2024): *NASA's Planetary Radar Spies (Another) Peanut-Shaped Asteroid* https://www.jpl.nasa.gov/images/pia26451-nasas-planetary-radar-spies-another-peanut-shaped-asteroid [Hozzáférés: 2024.10.20.]

NASA JPL CNEOS Center for Near Earth Object Studies (2024): *Sentry: Earth Impact Monitoring* https://cneos.jpl.nasa.gov/sentry/ [Hozzáférés: 2024.10.20.]

Köszönöm a figyelmet!